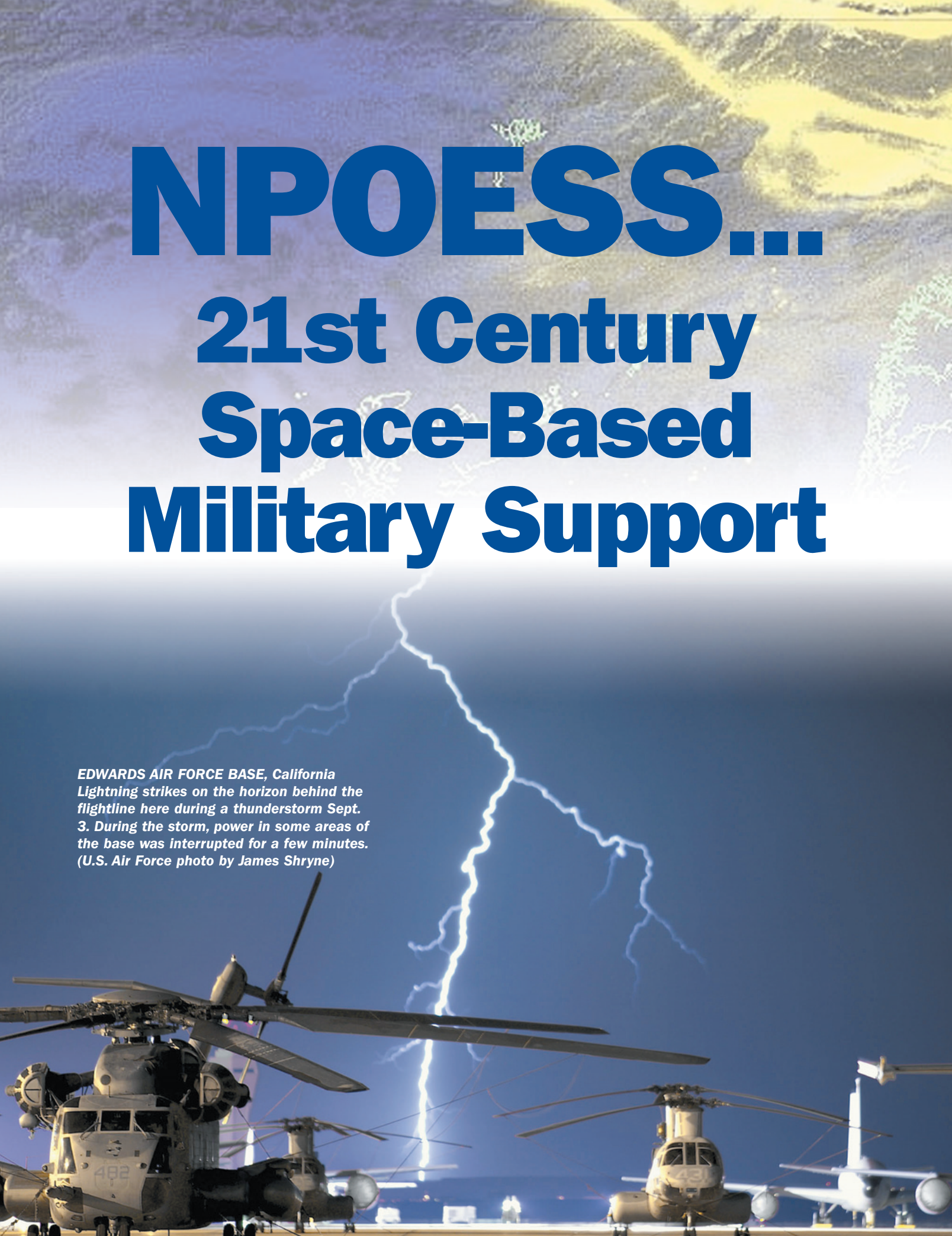
NPOESS...
21st Century Space-Based Military Support



EDWARDS AIR FORCE BASE, California Lightning strikes on the horizon behind the flightline here during a thunderstorm Sept. 3. During the storm, power in some areas of the base was interrupted for a few minutes. (U.S. Air Force photo by James Shryne)

Dave Jones
Craig Nelson
Lt. Col. Mike Bonadonna

This is the fourth in a series of articles on the National Polar-orbiting Operational Environmental Satellite System (NPOESS). In this article we review how NPOESS will support global military operations.

Introduction: Weather Warriors

Five days prior to the ground invasion of Iraq, Grey Beret Sergeant Charles Rushing crept under the cloak of darkness to Bubiyan Island, just off the Iraqi coastline. His mission was to study fog and surf trends along the shore in preparation for a nighttime helicopter raid and amphibious landing by U.S. and British Special Forces. His weather intelligence would provide critical information to helicopter pilots to navigate hazardous conditions on the night of the raid.

As U.S. and British Special Forces set out for the fog-enshrouded Iraqi coastline by air and sea, the U.S. Army's Third Infantry Division's Combat Weather Team (CWT) assembled at the northern Kuwaiti border with Iraq. They were tasked to produce weather analyses for mission-specific locations and to provide a near continuous stream of weather intelligence from inside Iraq.

Sandstorms and Snow

The ground war commenced on March 20, 2003, and the Third Infantry Division began its furious race through the desert toward Baghdad. As a front swept east across the Mediterranean, forecasters warned to prepare for "the mother of all fronts."

The largest sandstorm to hit southern Iraq in decades engulfed a 300-mile-wide area and blasted tremendous walls of dust into the atmosphere. Meanwhile, the Saddam Fedayeen (Saddam's "Men of Sacrifice") used the cover of the blinding storm to attack the stalled Army convoys.

The same system that blinded troops in southern Iraq created a different set of weather challenges for operations in northern Iraq. Sleet, snow, and heavy cloud cover over Bashur Airfield jeopardized a large and daring combat jump.

The Critical Nature of Weather Information

In Iraq, as in other military operations, weather can be either friend or foe. Ground observations can provide important "weather intelligence" about a particular area, however, they come with inherent risks for military personnel. Space-based Earth observing systems also provide critical information, usually with minimal risk.

In the 21st century, weather satellite systems will have higher spatial and temporal resolution for improved support of military operations. The foundation of that support will come from the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

Satellites provide an unprecedented and unique source of information for military operations. From support of ground troops to weapons deployment and the need to make rapid tactical decisions, Earth observation data are invaluable to our nation's global military mission. Polar-orbiting and geostationary satellites both play an important role, particularly in combat situations.

According to Brigadier General David L. Johnson, USAF (Retired), the Air Force Director of Weather from 2000 to 2003, input from the Combat Weather Team is a vital part of the mission planning process. "In the first three months of [the war on terrorism]," Johnson said, "15 percent of the targets ... and 30 percent of the weapons were changed as a result of what the weatherman said."

Weather Satellites and Warfare

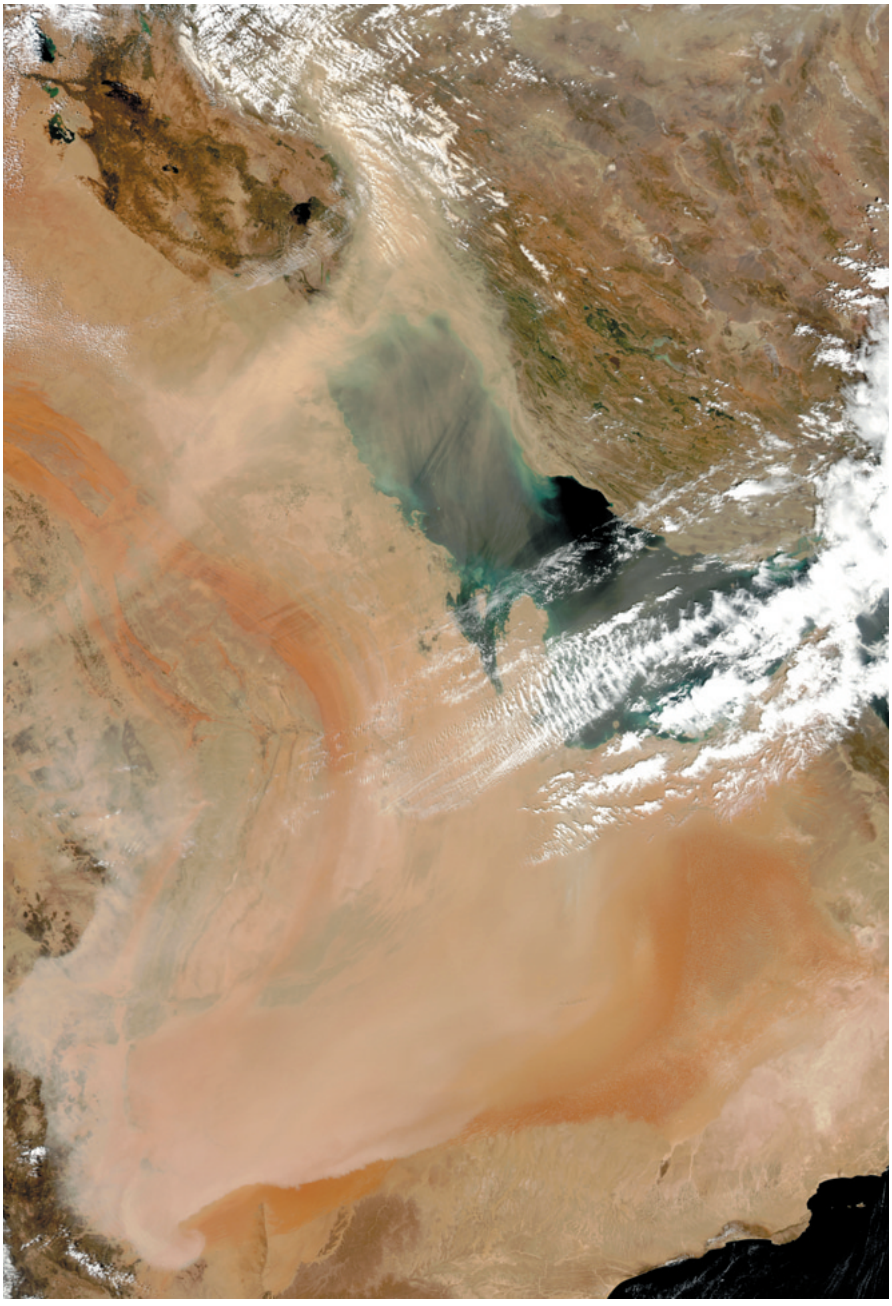
Shortly after the launch of the first civilian weather satellite in April 1960 (TIROS I—Television Infrared Observation Satellite) the Department of Defense (DoD) recognized the utility of earth imaging from space for military support. Beginning in 1962, low-Earth orbit weather satellites were launched to fly in front of imaging reconnaissance satellites to identify cloud-free areas of interest suitable for photography. These early operational weather satellites were later publicly identified as the Defense Meteorological Satellite Program (DMSP).

The Army-trained Air Force weather personnel parachute behind enemy lines and travel with a small platoon of soldiers, providing on-the-scene-weather information for a variety of missions. Image courtesy: Air Force Print News (AFPN)

Imagery: A Picture Is Worth a Thousand Words

History has shown that when users of satellite information work together with researchers to define the next generation of sensors, significant improvements arise and all benefit. The best characteristics of current imagers used on DMSP and on the National Oceanic and Atmospheric Administration's (NOAA) Polar-orbiting Operational Environmental Satellite (POES) spacecraft are being combined in the development of the Visible/Infrared Imager Radiometer Suite (VIIRS) that will fly on the NPOESS Preparatory Project (NPP) in 2006 and on NPOESS beginning in 2009. The VIIRS imager will detect atmospheric particles with much higher precision and clarity than is currently available to prepare those on the ground, over the sea, and in the air for rapidly changing environmental conditions.

The 22-channel (visible to long-wave IR) VIIRS will fly on NPP and on all NPOESS platforms to provide complete global coverage in one day at horizontal spatial resolutions of 370 m (for cloud imagery) and 740 m (for other products) at nadir. VIIRS will carry forward the capability to image at a near constant horizontal resolution across its ~3000 km swath. This is a significant improvement over current instruments. The near constant, high resolution is important because data at the edge of scan from real-time imagery may be the only information available for military field units in a specific area. VIIRS will also retain the DMSP capability of constant illumination across the day/night terminator and will be able to image from full nighttime conditions on one side of the Earth to the other side.



Dust storm across the Persian Gulf and Saudi Arabia captured on March 27, 2003 at 10:00 GMT (05:00 AM EST) by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board the NASA Aqua satellite. Image processed by StormCenter Communications. Aqua data retrieved from the MODIS Land Rapid Response system, GSFC, NASA.

Current military users of the multi-spectral features on the National Aeronautics and Space Administration's (NASA) Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on the Earth Observing System (EOS) Terra and Aqua satellites are paving the way for VIIRS. The U.S. Naval Research Laboratory (NRL) in Monterey, California pioneered multi-spectral techniques for MODIS in support of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF). NRL, Fleet Numerical Meteorology and Oceanography Center (FNMOC), Naval Central Meteorology and Oceanography Center (NCMOC) Bahrain, and the Air Force Weather Agency (AFWA) are currently using real-time multi-spectral images from MODIS to monitor and predict dust storms in the Middle East and Southwest Asia. These often violent storms interfere with troop and equipment movement, air operations, and weapons targeting. The multi-spectral techniques are also being used to support a variety of operational forces in battlefield situations. NRL, FNMOC, and Bahrain (NCMOC) ingested and produced near real-time imagery and disseminated value added products via Siprnet to coalition forces—in addition to data rehosted by AFWA and now being processed. Additionally, the military has access to near real-time imagery from other sectors of the world where environmental factors could impact operations.

Phenomena on the Earth's surface can also be imaged in the microwave portion of the electromagnetic spectrum. Although

providing lower spatial resolution pictures, microwave imagers have a distinct advantage because they can penetrate clouds and adverse weather conditions.

The passive microwave imager on NPOESS, the Conical-scanning Microwave Imager/Sounder (CMIS), will provide invaluable real-time data over the oceans for the Navy and for other operational units by imaging both wind speed and direction over open water. The CMIS instrument will improve quality of measurements over what is currently available from operational microwave imagers and will fly in each of the three NPOESS orbits.

Weather Forecasting for Military Operations

Sounding data (*i.e.*, atmospheric vertical temperature and moisture profiles) from POES and DMSP currently comprise approximately 90% of all the data assimilated into global numerical weather prediction models run at the Navy's FNMOC and at NOAA's National Centers for Environmental Prediction (NCEP). The advanced sounders on NPOESS are expected to lead to significant improvements in numerical weather prediction products in the next decade which are key to providing critical environmental information to planners and for long range missions.

Battlefield Tactics

Weather is considered in every facet of military planning, global deployment, and system design and evaluation. Last year, Peter B. Teets, Undersecretary of the Air Force, testified that "the nation's unparalleled ability to exploit weather and environmental data gathered from space is critical to the success of military operations." With improvements in environmental situational awareness, the U.S. military is rapidly shifting its tactical and strategic focus from "coping with weather" to anticipating and exploiting atmospheric and space environmental conditions for military advantage. New and improved data from NPOESS will significantly accelerate this transformation.

Weather affects every air mission, from an air drop of humanitarian aid to bombs on targets. While the effects of weather on ground-based aircraft can be serious,

This image taken from NASA's Space Shuttle shows a dust storm. Dust plumes are lifted from silt deposits in the desert valley and can cause visibility to be reduced to zero. The average height of the fine dust particles is three thousand to six thousand feet and can be picked up off the ground in winds as low as 15 knots.

carrier-based air wings often have more critical problems. Launching aircraft from the deck of a carrier is highly dependent on wind speeds. Part of the success of the air campaign in Operation Iraqi Freedom was attributed largely to good weather (for aircraft operations) throughout the period. However, nearly 65% of all air sorties that were cancelled were due to weather during a 3-day period at the end of March 2003.

The high-spectral fidelity imagery that will be available from VIIRS will present information in ways that will be more useful directly to the warfighter and allow Combat Weather Teams to answer tactical questions with more confidence. For example, improved cloud information will help make decisions regarding aerial refueling, the operation of infrared-guided missiles, and the formation of contrails, which can reveal stealth aircraft.

Ground forces are frequently at the mercy of the weather. Troops exposed to the elements are hampered by extreme temperatures, winds, dust, rain, and snow. With accurate weather forecasts and warnings, ground troops can prepare in advance for the extremes or camouflage themselves appropriately. The ability of the mechanized Army to move its weapons and equipment cross-country depends upon soil and vegetation type, soil moisture, precipitation, snow and ice cover. The CMIS instrument on NPOESS will provide leading-edge measurements of surface wetness and soil moisture. Combined with data on vegetation and soil type derived from VIIRS, these measurements will allow the Army to plan maneuvers more effectively for tactical advantage and safety.

Detailed real-time data on ocean surface winds from the CMIS instrument on NPOESS will help U.S. Navy task forces choose operating areas with favorable conditions for air operations. These

BALAD AIR BASE, Iraq—An Air Force pararescueman drops from an HH-60G Pave Hawk helicopter assigned to the 64th Expeditionary Rescue Squadron on March 30, 2003. U.S. Air Force photo by Staff Sgt. Aaron Allmon II

At sea aboard USS Abraham Lincoln *(CVN 72) Nov. 1, 2002—Lightning strikes on the horizon light up the bow of the aircraft carrier during a storm in the Arabian Sea.* Lincoln *and Carrier Air Wing Fourteen (CVW-14) are on a regularly scheduled six-month deployment conducting combat missions in support of Operation Enduring Freedom and Southern Watch. U.S. Navy photo by Photographer's Mate 2nd Class Aaron Ansarov.*

capabilities will help ensure that range-limited aircraft can complete strike missions and get back to their ship safely. Real-time data from CMIS on ocean surface winds, as well as other oceanographic products that will be derived from other NPOESS instruments or from prediction models that will use the surface winds fields derived from CMIS will assist the Navy in planning amphibious operations that depend critically on sea state. Water clarity and underwater visibility are becoming increasingly important to Navy SEAL Teams operating in the littoral regions of the world. Water clarity and turbidity in regions like the head of the Persian Gulf are being mapped today from the multi-spectral data from MODIS on NASA's EOS Terra and Aqua satellites and from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). These remote sensing capabilities will be carried forward with VIIRS.

The Navy uses ocean surface wind and wave fields for routine ship routing as well as to direct fleet sorties in emergency situations. Accurate, time-critical forecasts of hurricane tracks, strike probabilities, and landfall are essential to the Navy at home and overseas. Microwave and multi-spectral imagery as well as sounding data from NPOESS, combined with higher resolution Numerical Weather Prediction (NWP) models are expected to improve the accuracy of hurricane track and landfall forecasts. With better data and forecasts, the Navy will avoid costly unnecessary sorties and have more time in areas of certain impact.

The Global Theater

The U.S. military is a global force that is constantly responding to dynamic, quick changing environmental conditions in hostile territory or in areas where access to ground-based meteorological observations is extremely limited, dangerous to gather, or denied.

Operational polar-orbiting satellites, including DMSP, POES, EOS, and the future NPOESS, provide time-critical weather data globally to the military. In addition critical information is gathered from NASA research platforms EOS Terra and Aqua to support military operations.

The military value of weather data is directly linked to timely delivery of "fresh" and accurate products to mission planners and battlefield commanders. The constellation of three equally-spaced (in time) NPOESS satellites, combined with larger swath-widths will ensure complete contiguous global coverage with refresh rates (local average time interval between consecutive measurements of a parameter at the same location) of four hours at the equator with faster rates in polar latitudes.

The high spatial, temporal, and spectral resolution of the instruments on NPOESS would be wasted if the data were not coupled with an equally fast delivery system. The NPOESS SafetyNet data relay network and the NPOESS ground processing system will improve delivery of processed data to users by a factor of five to seven compared to DMSP and POES. Current tests of the prototype system are demonstrating that nearly 80% of the processed global NPOESS data will be available to users within 15 minutes and 95% of the data will be available within 24 minutes. According to John Cunningham, System Program Director for the NPOESS Integrated Program Office, "this jump in data latency means you'll actually be observing the weather while it's still fresh." Rapid ingest of new data into numerical weather prediction models will also facilitate improved nowcasts and forecasts.

NPOESS data will also be broadcast in real-time directly to combat units in the field or to carrier battle groups equipped with field terminals. Weather warriors attached to these units will receive NPOESS imagery and data for their area of interest as the satellite passes in range overhead. As technology improves, "net-centric" solutions may allow deployed units to be tied electronically into a larger infrastructure.

Improved weather information will significantly enhance the success of the Nation's global and "at home" military operations. Better global environmental observations can also help prevent new or renewed strife worldwide. Today, nations are increasingly vulnerable to environmental catastrophes that can threaten people, economic or political stability, and lead to regional conflicts over scarce environmental resources. Movement of populations from rural to urban centers, particularly in coastal regions, has created increased competition for resources such as water and arable land. These changes demand improvements in precipitation forecasts for food production, warnings of natural disasters, and seasonal climate and drought forecasts. Vice Admiral Conrad C. Lautenbacher, Ph.D., the Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator recently stated, "The forces of societal change and global development present new challenges for the world's leaders—challenges that will require future advances in our existing observing

NAVAL AIR STATION KEFLAVIK, Iceland—A HH-60G Pave Hawk helicopter from the 56th Rescue Squadron provides heavy lift/sling load support to the fishing trawler, the Baldvin Thorsteinsson. *The 56th Rescue Squadron, along with members of the 85th Maintenance Squadron, recently played a key role in the recovery efforts of the fishing trawler, which had been stranded on a sand bar off Iceland's southern coast for three days. (U.S. Air Force photo by Staff Sgt. Anthony Iusi)*

At sea aboard USS Kitty Hawk *(CV 63) May 27, 2002—Aerographer's Mate 3rd Class Keith Phillips from San Antonio, TX, prepares to launch a weather balloon. Weather balloons rise to a height of 20,000 feet and provide important weather data for the Kitty Hawk battle group. NPOESS data will significantly increase the frequency and density of atmospheric measurements similar to having millions of weather balloons.* Kitty Hawk *is the Navy's only permanently forward deployed aircraft carrier and is homeported in Yokosuka, Japan. U.S. Navy photo by Photographer's Mate Airman Lindsay R. Minturn.*

Master Sgt. Ray Perez, 4ID Aviation Brigade CWT, with a TVSAT and an IMETS (Integrated Meteorological System) setup in front of the newly named Baghdad International Airport. Weather data is critical to any military operation and receiver stations must be set up as soon as possible.

An Air Force MC-130P Combat Shadow refuels a Marine Corps CH-53E Super Stallion. The MC-130P flies clandestine or low visibility, low-level missions into politically sensitive or hostile territory to provide air refueling for special operations helicopters.

systems to the next level of Earth observation." The role of NPOESS as a critical component of NOAA's contribution to an Integrated Earth Observation System will be explored in the next article in this series.

Acknowledgments

Airforce Weather Agency: *https://afweather.afwa.af.mil*

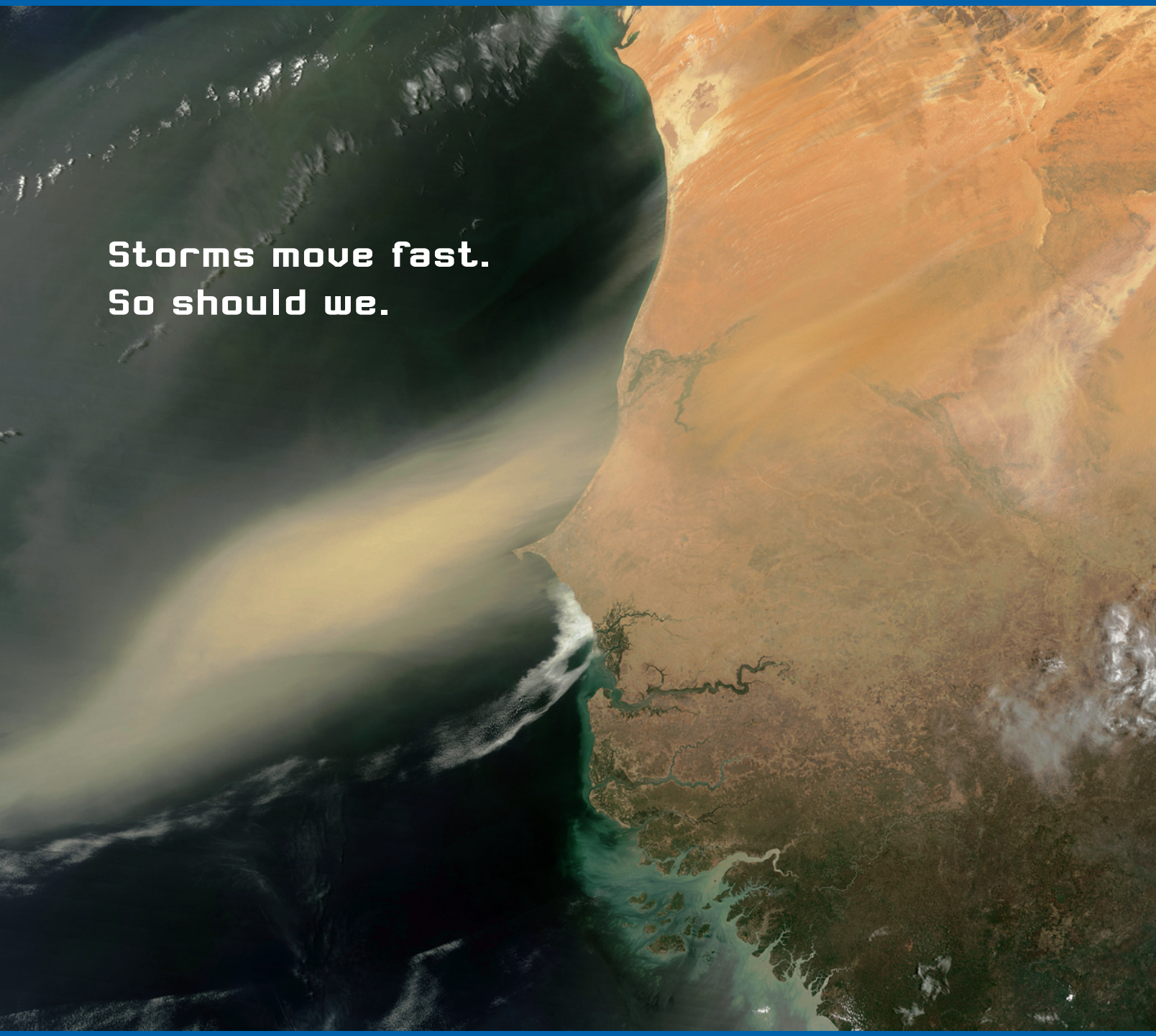
About the Authors

Dave Jones is Founder, President and CEO of StormCenter Communications, Inc. He is also President of the ESIP Federation *(esipfed.org)* and Chairman of the Board for the Foundation for Earth Science.

Craig Nelson is the former Executive Director of the NPOESS Integrated Program Office and can be reached at *Craig.Nelson@noaa.gov.*

Lt. Col. Mike Bonadonna is the Air Force User Liaison for the NPOESS Integrated Program Office and can be reached at *Michael.Bonadonna@noaa.gov.*

No, these are not clouds. This Defense Meteorological Satellite Program image uses a combination of infrared data with a specialized visual sensor that can see lights at night. The yellow streak shows a vigorous aurora over Norway and Sweden on October 30, 2003.



The fury of a fast-moving sandstorm is bad news. That's why we need the National Polar-orbiting Operational Environmental Satellite System (NPOESS). A remarkable technological leap, NPOESS images and data will improve warning times, giving warfighters an operational edge and an upper hand against a tough adversary — nature. The continued aggressive pursuit of NPOESS is critical because the technology is so widely beneficial. And the NPOESS team is moving quickly to make it happen.

Raytheon

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photo courtesy of MODIS Rapid Response Team at NASA, GSFC